Journal of Athletic Training 2020;55(7):673–681
doi: 10.4085/1062-6050-542-18

www.natajournals.org

Heat Policy Revision for Georgia High School Football Practices Based on Data-Driven Research

Earl R. Cooper, EdD, LAT, ATC, CSCS*; Andrew J. Grundstein, PhD†; Jessica D. Miles, PhD, LAT, ATC‡; Michael S. Ferrara, PhD, ATC, FNATA§; Patrick Curry, MS, ATC‖; Douglas J. Casa, PhD, ATC, FNATA, FACSM¶; Yuri Hosokawa, PhD, ATC#

Departments of *Kinesiology and †Geography, The University of Georgia, Athens; ‡The University of North Georgia, Dahlonega; §University of New Hampshire, Durham; ‖Greenwich Country Day School, CT; ¶University of Connecticut, Storrs; #Faculty of Sport Sciences, Waseda University, Tokorozawa, Saitama, Japan

Context: Interscholastic heat policies for football have not been evidence based. Therefore, their effectiveness in mitigating exertional heat illness has not been assessed.

Objective: To discuss the development of the Georgia High School Association heat policy and assess the effectiveness of revised guidelines.

Design: Descriptive epidemiology study.

Setting: Georgia high schools.

Patients or Other Participants: Interscholastic football players in grades 9 through 12.

Main Outcome Measure(s): Heat syncope and heat exhaustion (HS/HE) illness rates (IRs) were calculated per 1000 athlete-exposures (AEs), and relative risk (RR) was calculated as a ratio of postpolicy (POST) IR divided by prepolicy (PRE) IR.

Results: A total of 214 HS/HE cases (172 PRE, 42 POST) and 341 348 AEs (178 230 PRE, 163 118 POST) were identified. During the first 5 days of the PRE period, approximately 50% of HS/HE illnesses occurred; HS/HE IRs doubled when practice sessions increased from 2 to 2.5 hours and tripled for practices $\geq$3 hours. The HS/HE IRs in the PRE period increased from 0.44/1000 AEs for wet-bulb globe temperatures (WBGTs) of $<$82°F ($<$27.8°C) to $>$2.0/1000 AEs for WBGTs from 87°F (30.6°C) to 89.9°F (32.2°C). The RRs comparing PRE and POST policy periods were 0.29 for WBGTs of $<$82.0°F ($<$27.80°C), 0.65 for WBGTs from 82.0°F (27.8°C) to 86.9°F (30.5°C), and 0.23 for WBGTs from 87.0°F (30.6°C) to 89.9°F (32.2°C). No HS/HE illnesses occurred in the POST period for WBGTs at $>$90°F ($>$32.3°C).

Conclusions: Results from the PRE period guided the Georgia High School Association to revise its heat and humidity policy to include a mandated 5-day acclimatization period when no practices may exceed 2 hours and the use of WBGT-based activity-modification categories. The new policy reduced HS/HE IRs by 35% to 100%, depending on the WBGT category. Our results may be generalizable to other states with hot and humid climates similar to that of Georgia.

Key Words: exertional heat illness, wet-bulb globe temperature, football practice policy, interscholastic sports, American football

Key Points

- Heat syncope and heat exhaustion illness rates decreased by 35% to 100%, depending on the wet-bulb globe temperature category, over a 3-year period (2012–2014) after the Georgia High School Association revised its policy to mandate a 5-day acclimatization period with no practices exceeding 2 hours and the use of wet-bulb globe temperature-based activity-modification categories.
- Since implementation of the new heat policy (2012–2018), no heat-related deaths among Georgia High School Association schools have been recorded during fall football practice sessions.
- Although it is not possible to prevent all exertional heat illnesses and catastrophic events, these data were used to help develop a highly effective approach to mitigate the risk from heat-related illness.
- The process of close collaboration with stakeholders in developing policy and the final evidence-based heat guidelines can be used as a model for other state athletic organizations.

American football is a widely popular sport among high school athletes in the United States, with $>$10 000 schools offering football programs and hundreds of thousands of participants across the nation.[1] Exertional heat illnesses (EHIs) are a common hazard for football players, who are 11 times more likely to sustain an EHI than athletes in all other sports combined.[2] Most importantly, EHIs are among the top 3 causes of sudden death in these athletes.[3] In Georgia, awareness of the dangers of EHI peaked after the 2006 death of a Georgia high school football player, which received extensive media coverage, and with the knowledge that, over a 30-year period (1980–2009), Georgia led the country in heat-related deaths of interscholastic football players.[4,5]

Before 2012, heat safety guidelines for interscholastic football programs in Georgia were vague and offered no standardized practice recommendations for coaches to follow[6] (Appendix 1). For example, the 2010–2011 Georgia

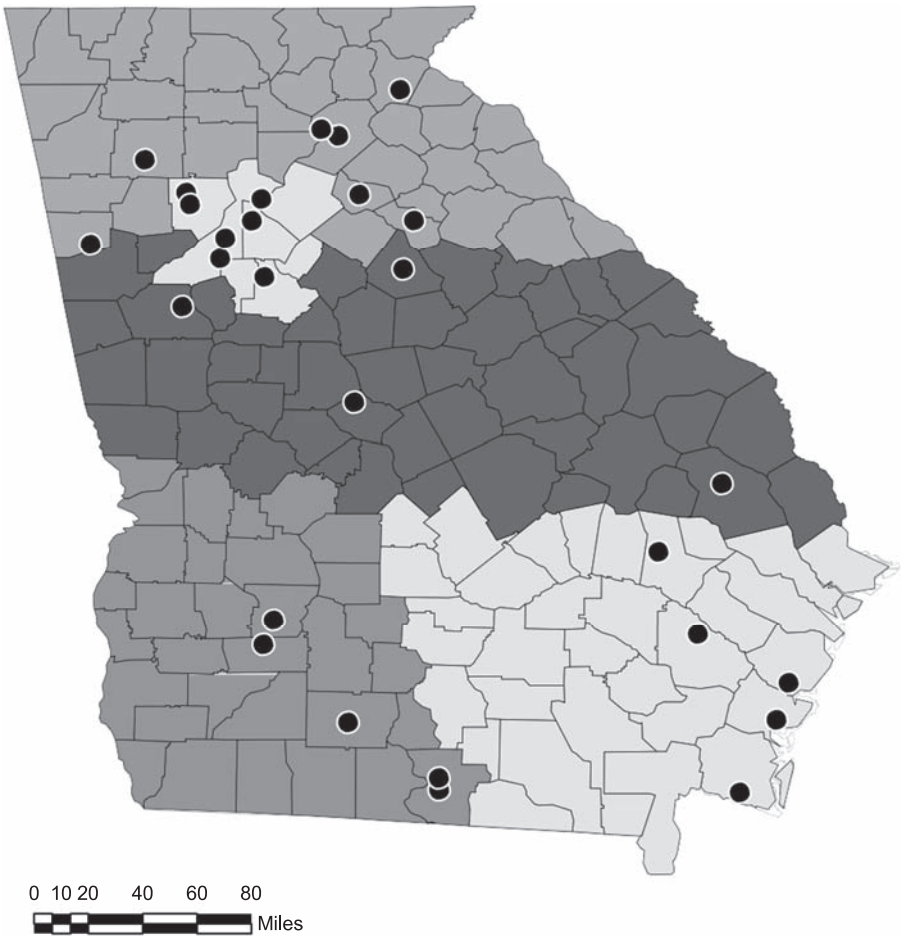

Figure 1. Georgia High School Association regions (North, Metro, Central, Southeast, and Southwest) and participating high schools (circles).

High School Association (GHSA) heat policy[6] required each school district to have its own written heat practice policy. This policy needed to include an environmental assessment to dictate when practices should be cancelled. However, the GHSA provided no evidence-based guidance for devising this policy.

In 2008, the GHSA decided to help develop a more comprehensive, data-driven heat policy. A 3-year study was funded to examine the relationship between environmental and practice conditions and EHI rates (illness rates [IRs]). In this investigation, environmental conditions that affect heat gains and losses and the frequency of exposure to hot environmental conditions, which influences acclimatization, were found to be key factors controlling EHI IRs. The results were used to develop a new evidence-based heat policy for preseason and regular season practices. The new heat policy[7] (Appendix 2) was implemented in the 2012 season and was applied uniformly to all GHSA member high schools. After the initial 3-year study was completed, GHSA funded another 3-year study to determine the effectiveness of the new policy in mitigating the risk of EHIs. The aims of this study were to (1) describe how the new evidence-based policy was developed and the data used in its design and (2) assess the performance of the new policy on EHI IRs between the prepolicy (PRE) and postpolicy (POST) periods.

METHODS

Participants

Data were collected for 6 consecutive football seasons (2009–2014) from 25 public and private interscholastic institutions that were member schools of the GHSA (Figure 1). Fall football seasons for the years 2009–2011 were designated as the PRE period and for the years 2012–2014 as the POST period. A number of considerations were used to identify the participating schools. First, all schools were required to have a full-time athletic trainer (AT) on site. Second, schools were selected to provide a representative sample both geographically and by school classification and enrollment. Therefore, schools were selected from among 5 geographic reporting regions in the state (ie, North, Metro [Atlanta], Central, Southeast, and Southwest), as determined by the Georgia Athletic Trainers' Association Executive Council. The size of each school was assessed based on the GHSA classification, ranging from A (smallest enrollment) to AAAAAA (largest enrollment) and included junior varsity and varsity athletes in grades 9 through 12. All regions were assigned an equal number of schools ($n = 5$) with equivalent enrollment numbers at the onset of the study. Every attempt was made to keep the number of participating schools and enrollments consistent per region. Two schools in the North and Central regions dropped out before the end of the 6-year study and were replaced with

Table 1. Definitions of Exertional Heat Illnesses[8]

Heat Illness	Description
Exercise-associated muscle cramps	Acute, painful, involuntary muscle contractions presenting during or after exercise
Heat syncope	Collapsing in the heat, resulting in loss of consciousness
Heat exhaustion	Inability to continue exercise due to cardiovascular insufficiency
Exertional heat stroke	Severe hyperthermia leading to overwhelming of the thermoregulatory system
Exertional hyponatremia	A serum sodium level of <130 mmol/L

schools of equal enrollment, giving those 2 regions 7 schools each that participated at some point in the study.

Practice Variables

Practice variables were practice duration, practice day (eg, first, second), and session number if multiple sessions occurred in a single day.

Exertional Heat Illness and Athlete-Exposure Definitions

We defined EHIs by using the National Athletic Trainers' Association (NATA) position statement on EHI[8] and applied the definitions throughout the entire 6-year study period. The position statement defined the various EHIs, including exercise-associated muscle cramps, heat syncope (HS), heat exhaustion (HE), exertional heat stroke, and exertional hyponatremia (Table 1). A reportable *athlete-exposure* (AE) followed the National Collegiate Athletic Association definition of an individual participating in 1 team session.[9,10] A reportable *EHI* was an event determined by the AT to result in a loss of participation such that the athlete was not capable of returning to play during that practice. The AT for each participating institution was responsible for documenting all EHIs, AEs, and wet-bulb globe temperature (WBGT) measurements during the practice session. These data were uploaded to a centralized data-management system via a Web-based portal.

Environmental Data

We used WBGT to measure environmental heat stress for the state of Georgia. Environmental assessment based on the heat index was determined to be inadequate. The heat index is calculated from ambient air temperature and humidity, assuming that the measurements are taken in the shade (ie, no radiant heating) for a person who is 5 ft, 7 in (1.70 m) tall; 147 lb (66.15 kg); wearing long pants and a short-sleeved shirt; and walking at 3 mi/h (1.34 m/s).[11] These assumptions do not represent football players or the practice conditions (eg, sun exposure and practice intensity) in which they engage. The WBGT is widely used in athletics as an accepted standard by the American College of Sports Medicine,[12] Sports Medicine Australia,[13] American Academy of Pediatrics,[14] and US Department of Defense.[15] The WBGT provides a more comprehensive measure of heat stress by including ambient air temperature, humidity, and radiant heat, which are important environmental factors influencing heat stress.[8] It also implicitly accounts for wind speed, which influences the wet-bulb temperatures. As a strictly environmental measure, the WBGT must be coupled with activity modification. Therefore, the WBGT was used to determine equipment modifications, number of rest breaks, and duration of practice sessions, as indicated in Table 2. QuestTemp-34 instruments (model QT-34; Quest Technologies, Oconomowoc, WI) were supplied to all participating schools for environmental assessment. Every 2 years, all sensors were recalibrated by the manufacturer to ensure instrument reliability and accuracy. The QT-34 measures WBGT, which is based on 3 environmental assessments: ambient air or dry-bulb temperature (DB), wet-bulb temperature (WB), and globe temperature (G). The WBGT was calculated as a weighted average of the 3 temperature measurements[16,17]: $\mathrm{WBGT} = 0.7\mathrm{WB} + 0.2\mathrm{G} + 0.1\mathrm{DB}$. The WBGT monitor was placed on a tripod 36 in (91.44 cm) above the ground, adjacent to the practice field to best capture heat-exposure conditions. The WBGT monitor stored environmental data on an internal memory card that was downloaded and transmitted to the research team. The

Table 2. Revised Georgia High School Association Activity-Modification Guidelines[35]

Wet-Bulb Globe Temperature, °F (°C)	Activity and Rest-Break Guidelines
<82.0 (<27.8)	Normal activities: provide at least 3 separate rest breaks each hour with a minimum duration of 3 min each during the workout.
82.0–86.9 (27.8–30.5)	Use discretion for intense or prolonged exercise; watch at-risk players carefully. Provide at least 3 separate rest breaks each hour with a minimum duration of 4 min each.
87.0–89.9 (30.6–32.2)	Maximum practice time is 2 h. For football: players are restricted to helmet, shoulder pads, and shorts during practice, and all protective equipment must be removed during conditioning activities. If the wet-bulb globe temperature rises to this level during practice, players may continue to work out wearing football pants without changing to shorts as long as the shoulder pads are removed. For all sports: provide at least 4 separate rest breaks each hour with a minimum duration of 4 min each.
90.0–92.0 (32.3–33.4)	Maximum practice time is 1 h. For football: no protective equipment may be worn during practice, and there may be no conditioning activities. For all sports: there must be 20 min of rest breaks distributed throughout the hour of practice.
>92.0 (>33.4)	No outdoor workouts. Delay practice until a cooler wet-bulb globe temperature level is reached.

Adapted with permission from the Georgia High School Association.

data were recorded every 15 minutes from the beginning to the end of a scheduled session. For analysis, the average WBGT for the session was used.

Procedures

Data were collected from the first official day of football practice (typically August 1 in the PRE period and July 25 in the POST period) until the last active calendar day in September. All schools adhered to the 2009–2011 GHSA heat and humidity policy in the PRE period and implemented the revised guidelines in the POST period. Both the environmental and EHI datasets were uploaded to a centralized database via a Web-based portal. The 2 datasets were merged and evaluated for accuracy; erroneous or duplicate data were removed.

Statistical Analyses

We recorded EHIs for all practice sessions. The data analyses focused on the more critical heat illnesses: HS, HE, and exertional heat stroke. During the 6-year study, no cases of exertional heat stroke were reported. Given the low numbers of HS and HE illnesses, these variables were combined to form 1 variable (HS/HE). The IRs were then calculated as HS/HE occurrences divided by 1000 AEs. The RRs of HS/HE IRs were used to evaluate the differences between the PRE and POST periods. We assessed RRs by GHSA WBGT categories to control for any differences in heat exposure during the 2 periods (Table 2).

The RR was computed as follows:

$$\mathrm{RR} = \frac{\mathrm{IR\_POST}}{\mathrm{IR\_PRE}}.$$

The standard error (SE) and confidence intervals (CIs) were calculated according to Daly[18] as follows:

$$\mathrm{SE}[\ln(\mathrm{RR})] = \sqrt{\frac{1}{a} + \frac{1}{c} - \frac{1}{a+b} - \frac{1}{c+d}},$$

where a is the number of HS/HE incidents in the POST period, c is the number of HS/HE incidents in the PRE period, $a+b$ is the total AEs in the POST period, and $c+d$ is the total AEs in the PRE period. The CIs were computed as follows:

$$\mathrm{CI} = \ln \mathrm{RR} \pm Z \cdot \mathrm{SE}(\ln \mathrm{RR}),$$

where Z is 1.645 for the 90% CIs and 1.96 for the 95% CIs. We observed no HS or HE incidents in the POST period for WBGTs from 90.0°F (32.3°C) through 92.0°F (33.4°C) and, therefore, could not calculate an RR for that category.

RESULTS

Policy Development of the GHSA

At the request of the GHSA, we collected data for 3 years (PRE period) to better understand the EHI risk among high school football players. In March 2012, a heat summit attended by members of the GHSA and experts in the EHI field was held on the campus of The University of Georgia to examine the findings. The key variables considered in developing a revised GHSA heat and humidity policy were practice day, practice duration, and WBGT measures, which had discernable effects on the EHI incidence. The first 5 days accounted for almost half of all HS/HE incidents over the 3-year PRE period (Figure 2). Additionally, we observed that, in the first 5 days, the HS/HE IRs doubled for practices lasting >2 hours and tripled for those lasting ≥3 hours compared with practices lasting <2 hours (Figure 3). On days 6 through 10, players could practice 30 minutes longer before a large increase in the HS/HE IR occurred (ie, 91–120 minutes on days 1–5 and 121–150 minutes on days 6–10; Figure 3). We also observed greater HS/HE IRs for practices lasting >3.5 hours for days 6 through 10 than for days 1 through 5 but speculate this may have been related to athletes wearing full equipment, which was allowed after day 5 in the original GHSA heat policy. We believe the greater HS/HE IRs for practices lasting >3.5 hours were higher for days 6 through 10 than for days 1 through 5 because the athletes were wearing full equipment and had no limitations on practice length or frequency, as allowed after day 5 in the original GHSA heat policy. Ultimately, we determined that practice sessions 1 through 5 should be no longer than 2 hours to mitigate EHI occurrences and allow for acclimatization. This period is consistent with the NATA acclimatization guidelines.[19]

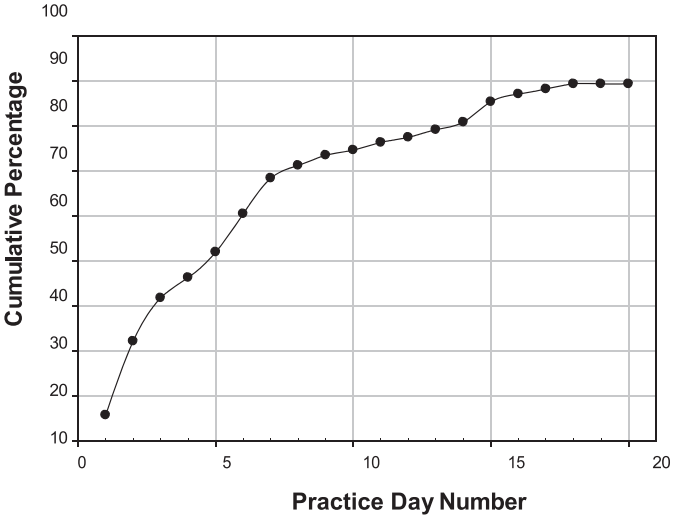

Figure 2. Cumulative heat-syncope and heat-exhaustion incidents (percentages) over the first 20 practice days during the prepolicy period.

Weather-based activity-modification thresholds were guided by the relationship between HS/HE IRs and WBGT. We reviewed HS/HE IRs in 1°F WBGT increments from <82°F (<27.8°C) to 92°F (33.4°C). For WBGTs of <82°F (<27.8°C), we found HS/HE IRs of <0.6/1000 AEs. As the WBGT increased from 82°F (27.8°C) to 86°F (30.0°C), we demonstrated greater IRs from 1.0 to 1.3/1000 AEs and a notable jump to >2.0/1000 AEs for WBGTs from 87°F (30.6°C) to 90°F (32.3°C). We observed a decrease in HS/HE IRs in the 90°F (32.3°C) to 92°F (33.4°C) category relative to the 87°F (30.6°C) to 89°F (31.7°C) category, which is likely due to a decrease in exposures, as many schools canceled outdoor practices. Therefore, we developed thresholds as shown in Table 2. Within these categories, we incorporated the recommendations set forth in the NATA position statement on fluid replacement for the physically active[20] and research conducted with US Marine Corps recruit trainees[15] to establish work-to-rest

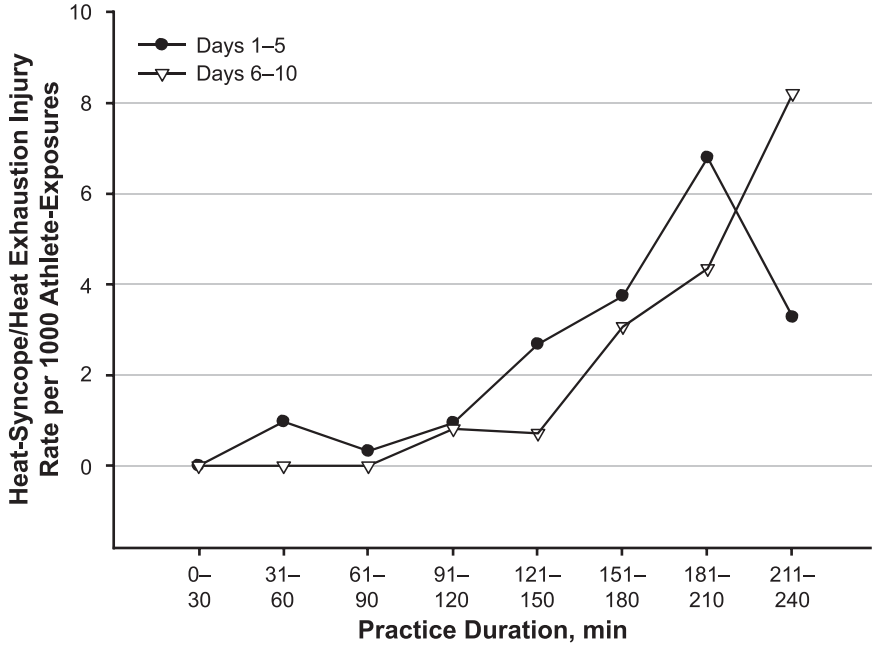

Figure 3. Heat-syncope and heat-exhaustion illness rate per 1000 athlete-exposures (AEs) during practice days 1 to 5 and 6 to 10 in the prepolicy period.

ratios for our WBGT categories. For example, three 3-minute rest breaks per hour were required for WBGTs from 82°F (27.8°C) to 86.9°F (30.5°C), with breaks increasing to 4 minutes per hour for WBGTs from 87°F (30.6°C) to 89.9°F (32.2°C).

Comparison of EHIs in the PRE Versus POST Policy Periods

We evaluated the HS/HE IRs in the PRE versus POST periods by WBGT category (Figure 4A). In all, 214 HS/HE incidents (172 PRE, 42 POST) occurred during 341 348 AEs (178 230 PRE, 163 118 POST). The HS/HE IRs in the PRE period increased by GHSA WBGT category from approximately 0.44/1000 AEs for WBGTs of <82°F (<27.8°C) to 0.95/1000 AEs in the 82°F (27.8°C) to 86.9°F (30.5°C) category and up to 2.10/1000 AEs in the 87°F (30.6°C) to 89.9°F (32.2°C) category. The HS/HE IRs for WBGTs from 90°F (32.3°C) to 92°F (33.4°C) were lower than those from 82°F (27.8°C) to 86°F (30.0°C) but had the next highest HS/HE rate at 1.70/1000 AEs. This result may be explained by reduced activity levels for some schools or even cancelled practice sessions when the WBGT was >90°F (32.3°C). The HS/HE IRs were uniformly lower in the POST period, with all IRs at <1.0/1000 AEs. The HS/HE IRs decreased in the POST relative to the PRE period by 35% to 100%, depending on the WBGT category (Figure 4B). Next, we assessed these changes in HS/HE IRs by using RRs and associated CIs (Table 3). An RR <1 indicated that the new policy reduced IRs. The RRs in the <82°F (27.8°C) and from 87°F (30.6°C) to 89.9°F (32.2°C) categories were 0.29 and 0.23, respectively, and were different at the 95% level. The RR in the 82.0°F (27.8°C) to 86.9°F (30.5°C) WBGT category was slightly greater (RR = 0.65) and different at the 90% level.

DISCUSSION

Heat-illness prevention strategies have been incorporated to successfully mitigate EHIs among US military personnel, as well as collegiate and professional athletes.[15,21–23] To our knowledge, this was the first longitudinal study to examine how policy guidelines for high school athletic practices can be modified using evidence-based research and the resultant reduction in HS/HE IRs. With recent data showing a dramatic increase in US deaths due to exertional heat stroke over the past 30 years,[1,24–26] this investigation was necessary to identify circumstances in which the EHI risk

Table 3. Relative Risk of Heat Syncope and Heat Exhaustion Illness Rates per 1000 Athlete-Exposures With Associated Confidence Intervals Over the Study Period

Wet-Bulb Globe Temperature, °F (°C)	Relative Risk	95% Confidence Interval	Relative Risk	90% Confidence Interval
<82.0 (<27.8)	0.29	0.16, 0.53	0.29	0.17, 0.48
82.0–86.9 (27.8–30.5)	0.65	0.39, 1.07	0.65	0.42, 0.99
87.0–89.9 (30.6–32.2)	0.23	0.10, 0.53	0.23	0.11, 0.46
90.0–92.0 (32.3–33.4)[a]	NA	NA	NA	NA
>92.0 (>33.4)[a]	NA	NA	NA	NA

Abbreviation: NA, not applicable.

[a] No heat-syncope or heat-exhaustion incidents were reported in the postpolicy period for wet-bulb globe temperatures of ≥90°F (≥32.3°C), so the relative risk could not be computed.

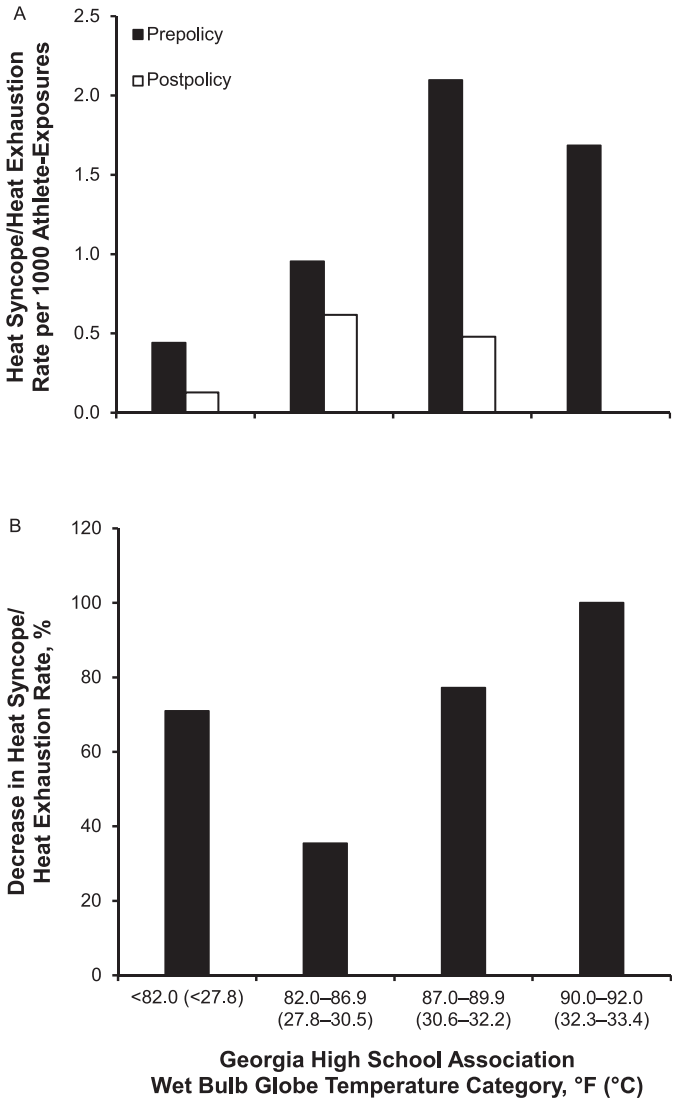

Figure 4. Comparison of, A, overall heat-syncope and heat-exhaustion illness rates in the prepolicy and postpolicy periods and, B, percentage of decrease in heat-syncope and heat-exhaustion illness rates in the postpolicy period relative to the prepolicy period.

was elevated and determine mitigation strategies to prevent catastrophic EHIs among the interscholastic population. In earlier epidemiologic studies, researchers[8,24–29] observed EHIs among interscholastic athletes, but none have evaluated the effect of practice policy changes on IRs. In the Translating Research into Injury Prevention Practice (TRIPP) model, Finch[30] proposed that a well-developed injury-prevention program be based on a critical analysis of injury-surveillance data (TRIPP stage 1) that allows elucidation of factors associated with injury incidence (TRIPP stage 2). Through this project, in which the EHI risk from environmental factors, behavioral patterns, and organizational rules was evaluated, Finch[30] identified where the risks were greatest and which variables could be changed or manipulated to reduce heat-related illnesses among participants.

Using data collected in the PRE period (eg, WBGT, practice day, and practice duration), we highlighted potential causes of EHIs and offered insight into ways to mitigate EHI risks beyond what is considered current best practice (TRIPP stage 3; Table 4).[8,12–14] Our study, with approximately 50% of all HS/HEs occurring within the first 5 practice days, fully supports the importance of a 5-day acclimatization period, as indicated in the NATA's position statement on EHI[8] (Figure 2). Furthermore, we found that HS/HE IRs increased markedly after 2 hours of continuous activity. Our results were consistent with the results of Tripp et al,[31] who reported that long, multihour practices led to higher EHI rates among high school football players in Florida. Therefore, practice duration should be considered when developing practice policies for the 5-day acclimatization period. The last major consideration from the PRE data was the association of EHIs and weather conditions: HS/HE IRs were observed in all GHSA WBGT categories but increased substantially in the 87.0°F (30.6°C) to 89.9°F (32.2°C) category. Such findings support the importance of adjusting work-to-rest ratios and activity based on environmental conditions.[32] Another unique part of our work was that the risks and subsequent mitigation strategies identified from the PRE period were addressed and tested in the POST period (TRIPP stage 4).[30] Indeed, HS/HE IRs were uniformly lower in the POST period, with all IRs at <1.0/1000 AEs, suggesting success from the heat policy changes within the studied cohort. The last stage of TRIPP (stage 6) is to evaluate the effectiveness of heat policies in a larger context.[30] The effectiveness of the 2009 NATA position statement on heat acclimatization was evaluated by Kerr et al,[33] who compared states that mandated or did not mandate the heat-acclimatization recommendations. They reported EHI rates were lower in states that mandated the recommendations (adjusted IR ratio = 0.45; 95% CI = 0.23, 0.87).[33] Similar analyses should be conducted in the future to evaluate the effectiveness of WBGT-based activity-modification guidelines in regions outside of Georgia that experience high EHI rates during interscholastic sport activity in the summer months.

Finally, a number of policy factors led to the widespread use of the policy and ultimately a reduction in EHIs among high school football players. It was important that the GHSA required all schools to adhere to a uniform heat-safety policy. Kerr et al[33] noted that the use of exertional heat-stroke management strategies was greater in schools with state-mandated guidelines. In addition, experience from implementing concussion policies described by Lowrey et al[34] indicated that state mandates and education are necessary but not sufficient; an enforcement mechanism is

Table 4. Summary of Heat-Syncope and Heat-Exhaustion Mitigation Measures and Proposed Policy Changes

Evidence	Mitigation Measure
About 50% of heat-syncope and heat-exhaustion incidents occurred in first 5 d	Mandatory 5-d acclimatization period
Heat-syncope and heat-exhaustion illness rates doubled for practices >2 h in first 5 d	Limit practices to <2 h in first 5 d
Increased heat-syncope and heat-exhaustion illness rates with increased wet-bulb globe temperature	Institute wet-bulb globe temperature-based activity and equipment-modification guidelines

also needed to ensure compliance. In Georgia, the GHSA has the clear enforcement authority and may fine schools up to $2500 if practices do not conform to guidelines.[35]

CONCLUSIONS

We discussed the process by which the GHSA adopted a data-driven heat policy. Using results from a 3-year study (2009–2011) of HS/HE IRs among high school football players, the GHSA revised its policy to mandate a 5-day acclimatization period with no practices exceeding 2 hours and using WBGT-based activity-modification categories. A comparison of the effectiveness of this policy was undertaken for a subsequent 3-year period (2012–2014). The HS/HE IRs decreased by 35% to 100%, depending on the WBGT category. Indeed, since the implementation of the new heat policy (2012–2018), no heat-related deaths among GHSA schools have been recorded during fall football practice sessions. Although it is not possible to prevent all EHIs and catastrophic events, our data were used to help develop a highly effective approach for mitigating the risk from heat-related illness. Moving forward, we hope that both the process of close collaboration with stakeholders in policy development and the final evidence-based heat guidelines can be used as a model for other state athletic organizations.

ACKNOWLEDGMENTS

Funding for this study was provided by the National Athletic Trainers' Association Research and Education Foundation, Carrollton, TX; Georgia High School Association, Thomaston, GA; National Federation of High Schools, Indianapolis, IN; and Georgia Athletic Trainers' Association, Atlanta, GA (Dr Cooper).

We thank Patrick Curry, MS, ATC, for his assistance with data collection, data management, and statistical analysis and Yuri Hosokawa, PhD, ATC, for her assistance with revision of the manuscript, especially the Discussion section. We also thank all of the athletic trainers who participated in this study.

REFERENCES

1. 2018-19 High school athletics participation survey. National Federation of High Schools Web site. https://www.nfhs.org/media/1020412/2018-19_participation_survey.pdf. Accessed December 18, 2019.
2. Kerr ZY, Casa DJ, Marshall SW, Comstock RD. Epidemiology of exertional heat illness among US high school athletes. *Am J Prev Med*. 2013;44(1):8–14.
3. Boden BP, Breit I, Beachler JA, Williams A, Mueller FO. Fatalities in high school and college football players. *Am J Sports Med*. 2013;41(5):1108–1116.
4. Carvell M. Dad says son who died in practice "pushed himself too hard." The Atlanta Journal Constitution Web site. http://www.ajc.com/sports/high-school/dad-says-son-who-died-practice-pushed-himself-too-hard/odqyJmxc8oU390CqDj8WMP/. Published August 3, 2011. Accessed July 6, 2017.
5. Grundstein AJ, Ramseyer C, Zhao F, et al. A retrospective analysis of American football hyperthermia deaths in the United States. *Int J Biometeorol*. 2012;56(1):11–20.
6. Constitution and by-laws 2011-2012. Georgia High School Association Web Site. https://www.ghsa.net/sites/default/files/documents/Constitution/GHSA_CBL_2011-2012.pdf. Accessed April 8, 2016.
7. Constitution and by-laws 2012-2013. Georgia High School Association Web Site. https://www.ghsa.net/sites/default/files/documents/Constitution/GHSA_CBL_2012-2013.pdf. Accessed June 2, 2016.
8. Binkley HM, Beckett J, Casa DJ, Kleiner DM, Plummer PE. National Athletic Trainers' Association position statement: exertional heat illnesses. *J Athl Train*. 2002;37(3):329–343.
9. Dick R, Agel J, Marshall SW. National Collegiate Athletic Association Injury Surveillance System commentaries: introduction and methods. *J Athl Train*. 2007;42(2):173–182.
10. Cooper ER, Ferrara MS, Casa DJ, et al. Exertional heat illness in American football players: when is the risk greatest? *J Athl Train*. 2016;51(8)593–600.
11. Rothfusz LP. The heat index equation (or, more than you ever wanted to know about the heat index). *NWS Technical Attachment SR 9023:2*. Fort Worth, TX: National Weather Service Southern Region Headquarters; 1990.
12. American College of Sports Medicine; Armstrong LE, Casa DJ, Millard-Stafford M, Moran DS, Pyne SW, Roberts WO. American College of Sports Medicine position stand: exertional heat illness during training and competition. *Med Sci Sports Exerc*. 2007;39(3):556–572.
13. Hot weather guidelines for sporting clubs and associations and the physically active. Sports Medicine Australia Web site. https://sma.org.au/sma-site-content/uploads/2009/05/hot-weather-guidelines-web-download-doc-2007.pdf. Accessed June 2, 2016.
14. Council on Sports Medicine and Fitness and Council on School Health, Bergaron MF, Devore C, Rice SG; American Academy of Pediatrics. Policy statement—climatic heat stress and exercising children and adolescents. *Pediatrics*. 2011;128(3):e741–e747.
15. Kark JA, Burr PQ, Wenger CB, Gastaldo E, Gardner JW. Exertional heat illness in Marine Corps recruit training. *Aviat Space Environ Med*. 1996;67(4):354–360.
16. Yaglou CP, Minard D. Control of casualties at military training centers. *AMA Arch Ind Health*. 1957;16(4):302–316.
17. Nybo L, Secher NH, Nielsen B. Inadequate heat release from the human brain during prolonged exercise with hyperthermia. *J Physiol*. 2004;545(2):697–704.
18. Daly LE. Confidence limits made easy: interval estimation using a substitution method. *Am J Epidemiol*. 1998;147(8):783–790.
19. Casa DJ, Csillian D; Inter-Association Task Force for Preseason Secondary School Participants, et al. Preseason heat-acclimatization guidelines for secondary school athletics. *J Athl Train*. 2009;44(3):332–333.
20. McDermott BP, Anderson SA, Armstrong LE, et al. National Athletic Trainers' Association position statement: fluid replacement for the physically active. *J Athl Train*. 2017;52(9):877–895.
21. Minard D. Prevention of heat casualties in Marine Corps recruits: period of 1955–60, with comparative incidence rates and climatic heat stresses in other training categories. *Mil Med*. 1961;126:261–272.
22. Guideline 2C: prevention of heat illness. In: Klossner D, compiler. *2013–14 NCAA Sports Medicine Handbook*. Indianapolis, IN: National Collegiate Athletic Association; 2013:39–42. National Collegiate Athletic Association Web site. https://www.ncaapublications.com/p-4328-2013-14-ncaa-sports-medicine-handbook.aspx. Published August 2013. Accessed September 9, 2019.
23. NFL Players Association. Collective bargaining agreement. NFL Communications Web Site. https://nfllabor.files.wordpress.com/2010/01/collective-bargaining-agreement-2011-2020.pdf. Published August 4, 2011. Accessed April 3, 2019.
24. Meuller FO, Colgate B. Annual survey of football injury research 1931–2009. Chapel Hill, NC: National Center for Catastrophic Sport Injury Research; 2010.
25. Mueller FO, Colgate B. Annual survey of football injury research 1931–2010. National Center for Catastrophic Sport Injury Research

Web site. http://nccsir.unc.edu/files/2014/05/2010FBAnnual.pdf. Published February 2011. Accessed September 7, 2019.
26. Dick R, Ferrara MS, Agel J, et al. Descriptive epidemiology of collegiate men's football injuries: National Collegiate Athletic Association Injury Surveillance System, 1988–1989 through 2003–2004. *J Athl Train*. 2007;42(2):221–233.
27. Kerr ZY, Marshall SW, Comstock RD, Casa DJ. Implementing exertional heat illness prevention strategies in US high school football. *Med Sci Sports Exerc*. 2014;46(1):124–130.
28. Kerr ZY, Casa DJ, Marshall SW, Comstock RD. Epidemiology of exertional heat illness among U.S. high school athletes. *Am J Prev Med*. 2013;44(1):8–14.
29. Kerr ZY, Yeargin SW, Hosokawa Y, Hirschhorn RM, Pierpoint LA, Casa DJ. The epidemiology and management of exertional heat illness in high school sports during the 2012/13-2016/17 academic years [published online ahead of print June 6, 2019]. *J Sport Rehabil.* doi:10.1123ljsr.2018-0364.
30. Finch C. A new framework for research leading to sports injury prevention. *J Sci Med Sport*. 2006;9(1–2):3–10.
31. Tripp BL, Eberman LE, Smith MS. Exertional heat illness and environmental conditions during high school football practices. *Am J Sports Med*. 2015;43(10):2490–2495.
32. Cooper ER. What are the best methods of assessing environmental conditions and what modifications should be made to work-rest ratios, practices, and games based on the environment? In: Sauers EL, Lopez RM, eds. *Quick Questions in Heat-Related Illness and Hydration: Expert Advice in Sports Medicine*. Thorofare, NJ: SLACK, Inc; 2015:133–136.
33. Kerr ZY, Register-Mihalik JK, Pryor RR, et al. The association between mandated preseason heat acclimatization guidelines and exertional heat illness during preseason high school American football practices. *Environ Health Perspect*. 2019;127(4):47003.
34. Lowrey KM, Morain SR. State experiences implementing youth sports concussion laws: challenges, successes, and lessons for evaluating impact. *J Law Med Ethics*. 2014;42(3):290–296.
35. Georgia High School Association. Constitution and by-laws 2019-2020. Georgia High School Association Web site. https://www.ghsa.net/sites/default/files/documents/Constitution/Constitution19-20Completecx3.pdf. Accessed August 5, 2019.

Address correspondence to Earl R. Cooper, EdD, LAT, ATC, CSCS, Department of Kinesiology, The University of Georgia, 330 River Road, 371 Ramsey Center, Athens, GA 30602. Address e-mail to cooperb@uga.edu.

Appendix 1. Policy in Effect During Prepolicy Period. Georgia High School Association Constitution and By-Laws 2010-2011.[6(pp37,64)] Reprinted with permission from the Georgia High School Association.

Section 2

2.67 Practice Policy for Heat and Humidity:

(a) Each member school shall have a written policy for conducting practices in all sports during times of extremely high heat and/or humidity that will be signed by each head coach and distributed to all players. The policy shall include, but is not limited to:
  (1) the time of day the practices are to be scheduled at various heat/humidity levels
  (2) the ratio of workout time to time allotted for rest and hydration at various heat/humidity levels
  (3) the heat/humidity levels that will result in outdoor practices being terminated

(b) A scientifically-approved instrument that measures the heat index must be utilized at each practice to ensure that the written policy is being followed properly.

(c) Schools may determine the heat/humidity levels using either wet bulb globe temperature readings or heat index readings.

Section 5

D. Football practice may begin no earlier than August 1st.

1. In the first five days, at least two days must have practices with players dressed in shorts, helmets, shoulder pads, mouthpieces and shoes only. The other three days MAY include practices that have players in full pads, but no more than two consecutive days of the first five days may have full pads in use. Coaches are not required to have any practices in full pads during the first five days of practice.

At school workouts from the end of school in the spring until the first day of practice in the fall, players may wear no other protective football equipment except helmets and mouthpieces for all voluntary workouts and passing league games. NOTE: Any modification of this equipment rule in summer camps requires the approval of the Executive Director.

Appendix 2. Policy in Effect During Postpolicy Period. Georgia High School Association Constitution and By-Laws 2012-2013.[7(pp38–39,66–67)] Reprinted with permission from the Georgia High School Association.

Section 2.67

Practice Policy for Heat and Humidity:

(a) Schools must follow the statewide policy for conducting practices and voluntary conditioning workouts in all sports during times of extremely high heat and/or humidity that will be signed by each head coach at the beginning of each season and distributed to all players and their parents or guardians. The policy shall follow modified guidelines of the American College of Sports Medicine in regard to:
  (1) The scheduling of practices at various heat/humidity levels
  (2) The ratio of workout time to time allotted for rest and hydration at various heat/humidity levels

(3) The heat/humidity levels that will result in practice being terminated

A scientifically-approved instrument that measures the Wet Bulb Globe Temperature must be utilized at each practice to ensure that the written policy is being followed properly.

WBGT	Activity Guidelines and Rest Break Guidelines
Under 82.0	Normal Activities – Provide at least three separate rest breaks each hour with a minimum duration of 3 minutes each during the workout.
82.0–86.9	Use discretion for intense or prolonged exercise; watch at-risk players carefully. Provide at least three separate rest breaks each hour with a minimum duration of 4 minutes each.
87.0–89.9	Maximum practice time is 2 hours. For Football: players are restricted to helmet, shoulder pads, and shorts during practice, and all protective equipment must be removed during conditioning activities. For All Sports: Provide at least four separate rest breaks each hour with a minimum duration of 4 minutes each.
90.0–92.0	Maximum practice time is 1 hour. For Football: no protective equipment may be worn during practice, and there may be no conditioning activities. For All Sports: There must be 20 minutes of rest breaks distributed throughout the hour of practice.
Over 92.1	No outdoor workouts. Delay practice until a cooler WBGT level is reached.

(b) Practices are defined as: the period of time that a participant engages in a coach-supervised, school-approved sport or conditioning-related activity. Practices are timed from the time players report to the practice or workout area until players leave that area.

(c) Conditioning activities include such things as weight training, wind-sprints, timed runs for distance, etc., and may be a part of the practice time or included in "voluntary workouts."

(d) A walk-through is not a part of practice time regulation, and may last no longer than one hour. This activity may not include conditioning activities or contact drills. No protective equipment may be worn during a walk-through.

(e) Rest breaks may not be combined with any other type of activity and players must be given unlimited access to hydration. These breaks must be held in a "cool zone" where players are out of direct sunlight.

Section 5

D. Football practice may begin five consecutive weekdays prior to August 1st.

1. In the first five days of practice for any student, the practice may not last longer than two (2) hours, and the student may wear no other protective football equipment except helmet and mouthpieces. NOTE: The time for a session shall be measured from the time the players report to the practice or workout area until they leave that area.
2. Beginning August 1st, any student may practice in full pads and may practice a maximum of two times in a single calendar day under the following stipulations:
   (a) A student must have participated in five conditioning practices wearing no other protective football equipment except helmet and mouthpieces before being allowed to practice in full pads.
   (b) If two workouts are held in a single calendar day:
      (1) No single session may last longer than three (3) hours.
      (2) The total amount of time in the two practices shall not exceed five (5) hours.
      (3) There must be at least a three-hour time of rest between sessions.
      (4) There may not be consecutive days of two-a-day practice sessions. All double-session days must be followed by a single-session day or a day off.
   (c) These procedures are derived from recommendations created by the Inter-Association Task Force for Preseason Secondary School Athletics Participants in the paper "Preseason Heat-Acclimatization Guidelines for Secondary School Athletes."

From the end of school in the spring until the first day of preseason practice, players may wear no other protective football equipment except helmets and mouthpieces for all voluntary workouts and passing league games. Institutional heat policies are also in effect for voluntary workouts supervised by school personnel.